ARIZONA DEPARTMENT OF ADMINISTRATION

Office of Employment & Population Statistics

Arizona Sub-County Population Projections, 2013-2050: Methodology Report

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1. BACKGROUND

Arizona Sub-County Population Projections (2013 edition) are prepared in accordance with Executive Order 2011-04 signed by Governor Janice Brewer. Relevant sections are presented below:

> Section 1: The Arizona Department of Administration (ADOA) shall be the agency designated to produce the official population estimates and projections for the State of Arizona.
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> Section 4: ADOA shall produce the official population projections for each year for a minimum of the next 25-year period. The projections shall be dated as of July 1 and shall include projections for the State, its counties, its incorporated jurisdictions, and the unincorporated balance of each county.
>
> Section 6: ADOA shall release the projections for the State's incorporated jurisdictions and the unincorporated balance of each county as soon as possible following the release of the State and county projections, but no later than nine months thereafter.

Executive Order 2011-04 also allows ADOA to incorporate sub-county projections made by Regional Councils of Governments (COGs):

> Section 8. … The Regional Councils of Governments shall submit population projection data for incorporated jurisdictions and the unincorporated balance of the counties to ADOA no later than six months after ADOA's release of State and county population projections in order to be included in ADOA's projections.

Central Arizona Governments (CAG), Maricopa Association of Governments (MAG), and Pima Association of Governments (PAG) made population projections for their respective member agencies in Gila, Pinal, Maricopa, and Pima counties. These projections are reviewed and adopted by ADOA and are released along with sub-county projections made by ADOA for places in the other 11 counties. CAG, MAG, and PAG each provided its own methodology statement. The methods described in this document apply to the projections made by ADOA.

Executive Order 2011-04 further directs the use of these projections:

> Section 10: Population estimates and projections produced by ADOA in accordance with this Executive Order shall be used by all State agencies for all purposes, including those required by federal law, which necessitates the development of population estimates or population projections.

2. METHODOLOGY

Development of the sub-county projections began with research into several different methods of population projection. Each method used different amounts of historical data and produced a wide range of results, some of which revealed inherent problems with their structures. The methods are briefly described below:

Constant Share Method:

$$P_{it} = (P_{il}/P_{jl})\, P_{jt}$$

where,

P_{it} is the population projection for small area *(i)* in the target year *(t)*;
P_{il} is the actual or estimated population for small area *(i)* in the launch year *(l)*;
P_{jt} is the population projection for larger area *(j)* in the target year *(t)*;
P_{jl} is the actual or estimated population for larger area *(j)* in the launch year *(l).*

The Constant Share method assumes that the share of a place's population of a county remains constant over the projection horizon. This might not be a reasonable assumption for some places. The method forces places to grow at the same rate as the county, which may also be unreasonable in some areas.

Shift-Share Method:

$$P_{it} = (P_{jt})\, [(P_{il}/P_{jl}) + ((z/y)\, ((P_{il}/P_{jl}) - (P_{ib}/P_{jb})))]$$

where,

b denotes the base year;
z is the number of years in the projection horizon (between launch year and year *t*);
y is number of years in the base period.

The Shift-Share method accounts for changes in population shares over time. Over long projection horizons, it can lead to population losses for small areas that had declined or grew very slowly during the base period. It can result in a negative population.

Share-of-Growth Method:

$$P_{it} = P_{il} + [(P_{il} - P_{ib})/(P_{jl} - P_{jb})]\, (P_{jt} - P_{jl})$$

The Share-of-Growth method assumes that a place's share of county growth will be the same over the projection period as in the base period. This can result in a negative population. Also, when the direction of growth for a place is opposite that of the county, the method incorrectly distributes the growth.

Plus-Minus Distribution:

$$POSFACTOR = [ABSUM + (CNTRLCHG - SUM)]/ABSUM$$

$$NEGFACTOR = [ABSUM - (CNTRLCHG - SUM)]/ABSUM$$

where,

SUM is the sum of the population changes experienced by each place within the base period;
ABSUM is the sum of the absolute values of the population changes experienced by each place within the base period;
CNTRLCHG is the projected county population change between the launch year and the target year.

The Plus-Minus method distributes the county population change to places based on the change occurring within the base period. POSFACTOR and NEGFACTOR are applied to a place's growth since the launch year based on the direction of that growth. This takes into account that some places experienced growth in the opposite direction of its county. However, places with zero population may not receive any adjustment, and results can be negative.

The methods described above are collectively referred to as "ratio methods."

GIS Boundary Matching

Although most incorporated places existed in 1990 and 2000, many Census Designed Places (CDPs) that existed in 2010 did not in previous decennial censuses. Even if a CDP of the same name had existed for the previous censuses, it may have covered a much smaller or much larger area. Utilizing 2010 place boundaries and block-level census data and maps from 1990 and 2000, we created historical data for 1990 and 2000 for each place. These data were used as alternative base data for the ratio methods we researched. If the historical data were correct, we would see a more accurate picture of where growth occurred in the CDPs. However, we suspect that this method did not work correctly in some counties due to inaccurate maps or block-level population data, especially for 1990. Instead of being used as inputs to create draft projections, these data were ultimately employed as a tool for discussion with the jurisdictions to better understand areas on a case-by-case basis.

Forecast Model:

Intercensal estimates for 1980-2010 and postcensal estimates for 2010-2012 were used as input to the SPSS 21 forecasting procedure for each incorporated place and unincorporated balance of county. The optimal forecast model (ARIMA, Holt, Brown, or Simple exponential smoothing model) for each place was chosen algorithmically by SPSS and used to forecast population from 2013 to 2050.

None of the methods reviewed were appropriate for all places. In many cases, the results of the ratio methods projected negative population or an unreasonable rate or direction of growth for

smaller places. The forecast models[1] were chosen to produce the preliminary population projections for incorporated places and the unincorporated balance of counties because they were based on many more historical data points than the ratio methods and produced a higher percentage of feasible projections. These results were adjusted proportionately to achieve agreement with the official published population projection for each county. The population for each CDP was then created by distributing the adjusted balance of county estimates according to the Census 2010 share of the balance of county population.

Regional councils of government and several jurisdictions reviewed the preliminary projections. Their local knowledge about planned economic development, resource constraints, and demographic patterns in specific areas guided adjustments to the preliminary projections. Several rounds of consultation were conducted before the sub-county projections were finalized.

3. LOCAL KNOWLEDGE AND ADJUSTMENTS

Adjustments to the preliminary sub-county projections were made on a case-by-case basis to create a reasonable picture of population change within each county. Whenever possible, the most recent general plans for incorporated places were reviewed and used as a "reasonableness check" on the preliminary and revised population projections. Implied population densities resulting from the projections were also reviewed for feasibility[2]. The description of adjustments is provided below. Final projections for places that are not addressed in the sections below are equivalent to the preliminary numbers.

Apache County:
All three incorporated places expect growth in the near-to-mid-term future due to two potash mines and a CO_2 pipeline. Based on comments from NACOG, 200 people were added to the preliminary 2020 projection for Springerville. The resulting growth rate was used to obtain the 2020 populations for St. Johns and Eagar. Then, an additional 200 was added to St. Johns' 2020 population assuming that it would be impacted even more due to its proximity to the mines. Linear interpolation was used to project population for 2013-2019. For all three places, 15 percent growth was assumed between 2020 and 2030 based on comments from NACOG. Linear interpolation was again used for the years in between. Given the start of a declining trend for the county as a whole, population was held constant for the three places beyond 2030. The assumption was that demographic forces that bring about population decline will be counter balanced by continued economic activities, resulting in a somewhat stable population.

[1] Model statistics are available upon request for all incorporated places and the balances of county.
[2] MAG, CAG, and PAG produced their projections with land use models, which provided guidance to EPS on what population densities could be reasonably achieved over the horizon. All places within the state have sufficient room within the current geographic boundaries for the projected growth and do not require the assumption of future annexations.

McNary's growth rate was set at the annualized rate of the Navajo County portion of the Fort Apache Reservation between 2000 and 2010. All other unincorporated areas were adjusted proportionately to bring the total population in line with the county control.

Coconino County:
Direct adjustments were first made to four places. As background, growth in Flagstaff was 36 percent and 72 percent of the county's growth in the 1990s and 2000s, respectively. It was assumed that the growth in Flagstaff in the projection horizon to 2050 will be equal to 80 percent of the county's growth. Annual growth resulting from the preliminary projections was adjusted to meet this assumption. Populations in Fredonia and Tusayan were held constant from 2012 onward. Finally, Sedona's population was extrapolated using the linear trend from 1990-2010, which is the same logic used for its Yavapai part.

All CDPs were proportionately adjusted and re-evaluated for additional changes. We chose to hold the population of Supai constant at 209[3] from 2012 onward. We also adjusted Grand Canyon Village based on local consensus that it may grow to 2,150 in 2050. That figure was assigned to 2050, and linear interpolation was used for the years in between. The remaining CDPs were proportionately adjusted one more time for the final results.

Cochise County:
Guided by feedback from SEAGO, we assumed that Sierra Vista will experience a growth of 20,000 between 2010 and 2050. We distributed these 20,000 people across the annual change predicted by the forecast model over the projection horizon. The population of Tombstone was held constant from 2012 onward in contrast to the continued decline shown by preliminary numbers. Feedback also suggested that the original projections for Benson, Bisbee, and Naco CDP were too low. Given the changes to Sierra Vista and Tombstone, adjustments were made proportionately to Benson, Bisbee, and Naco to bring the county total population in line with the control.

Greenlee County:
SEAGO suggested that projections for all places in the county were too low. Since the published county control does not coincide with SEAGO's expected growth at the place level, we were not able to revise projections upward. We decided to revisit this county after July 1, 2013 estimates are published. If official July 1, 2013 population estimates are significantly higher than the population projections currently in place for July 1, 2013, we might need to revise the county and sub-county projections.

Graham County:
No changes were made to the preliminary projections.

[3] This is 45% of the average population of the Havasupai Reservation over the last three censuses.

Gila County:
Official sub-county projections for this county were produced by Central Arizona Governments (CAG). They were reviewed and adopted by EPS at ADOA. The CAG methodology can be found at https://population.az.gov/sites/default/files/documents/files/pop-prj-pinal-gila-2013methodology.pdf.

La Paz County:
Comments from WACOG led us to assume that Bouse, Ehrenberg, Vicksburg, and Wenden CDPs will grow annually at the same rate as the county over the 40-year horizon. Parker Strip and Salome CDPs will return to their 2000 population levels in 2050, and linear interpolation was used to obtain projections for the years in between. Quartzsite and the small balance of county (i.e. unincorporated areas that are not part of a CDP) were adjusted proportionately so that the county control was met.

Maricopa County:
Official sub-county projections for this county were produced by Maricopa Association of Governments (MAG). They were reviewed and adopted by EPS at ADOA. The MAG methodology can be found at https://population.az.gov/sites/default/files/documents/files/pop-prj-maricopa-municipal-2013methodology.pdf.

Mohave County:
Bullhead City and Kingman were assumed to grow annually like the county. All CDPs were adjusted proportionately and re-evaluated. Eight CDPs[4] that were deemed unlikely to grow had their population held constant from 2012 onward. New Kingman-Butler CDP was recalculated using half the annualized rate it experienced between 2000 and 2010. The four CDPs[5] which were expected to take on more growth were then proportionately adjusted upward.

Navajo County:
In Navajo county, we adjusted the projection for Winslow based on information about the construction of a wood mill. The assumption is that an estimated 900 jobs will be created by the construction and milling operations. Some of these jobs will be filled locally from the existing population; the jobs will also attract additional labor force and family from outside of the area. We assumed that the ultimate impact on population is 900. The jobs would be filled gradually by 2020, at which point the population will remain constant until 2050[6].

Two potash mines will drive growth in Holbrook, which we assumed would take on the same annual growth rate as the county. The remaining four incorporated places in the county were projected using the share-of-growth method with base data from Census 2000 and Census 2010.

[4] Chloride, Kaibab, Katherine, Littlefield, Oatman, Truxton, Valentine, and Wikieup.
[5] Dolan Springs, Fort Mohave, Meadview, and Valle Vista.
[6] The deforestation project is expected to last only 10 years. Thus, population will be unlikely to continue to increase due to this industry.

We allowed CDPs on the Navajo Reservation to decline by -18 percent over the projection horizon, which translates into an annualized rate that is approximately the same as the annualized growth (actually, decline) rate in the 2000-2010 period. This is also consistent with the projected population decline in the Apache County portion of the reservation. The remaining CDPs used the constant share method based on Census 2010 data.

Pima County:
Official sub-county projections for this county were produced by Pima Association of Governments (PAG) in cooperation with ADOA. They were reviewed and adopted by EPS at ADOA. The PAG methodology can be found at https://population.az.gov/sites/default/files/documents/files/pop-prj-pima-2013methodology.pdf.

Pinal County:
Official sub-county projections for this county were produced by Central Arizona Governments (CAG). They were reviewed and adopted by EPS at ADOA. The CAG methodology can be found at https://population.az.gov/sites/default/files/documents/files/pop-prj-pinal-gila-2013methodology.pdf.

Santa Cruz County:
The constant share method was used for all places from 2013-2050 based on estimates for July 1, 2012.

Yavapai County:
For Camp Verde, Chino Valley, Clarkdale, Cottonwood, and Dewey-Humboldt, we used the share-of-growth method with Census 2000 and Census 2010 as the endpoints. Wickenburg was held constant at 18 from 2012 onward. All CDPs and the small balance of county were then adjusted proportionately to account for the change in projections for the six incorporated places.

Prescott and Prescott Valley were adjusted to grow at one-third the 2000-2010 annualized rate. The effect was that Prescott Valley overtakes Prescott in 2014 following feedback that this will occur soon. We extrapolated the 1990-2012 growth linearly for Sedona from 2012 onward and assumed that Village of Oak Creek would grow like Sedona. Verde Village was assumed to follow Cottonwood's annual growth. The feedback from NACOG suggests that these two places are very similar.

Population levels for Bagdad, Seligman, and Yarnell were kept constant from 2012 onward, while Peeples Valley and Williamson were extrapolated at half the linear growth between 2000 and 2010 over the projection horizon. Cordes Lakes, Lake Montezuma, Paulden, and Spring Valley were adjusted to take on additional growth and bring the sum of population in line with the county control.

Yuma County:
Somerton was set to grow at 20, 30, and 35 percent of the 2000-2010 annualized rate in 2013, 2014, and 2015, respectively, ramping up to 40 percent of the 2000-2010 annualized rate in 2016 to 2030. These assumptions resulted in a projected population slightly less than the city's general plan build-out medium projection for 2030. Growth is slowed to 30 percent of the 2000-2010 annualized rate for 2031-2050, producing a 2050 population projection that is close to the general plan's high build-out projection for 2030.

Wellton was assumed to grow linearly from 2016 to 2050 at the rate experienced between 2000 and 2012. However, in 2013, 2014, and 2015, 40, 60, and 80 percent of the linear rate was used to facilitate a smooth transition from the short-term pattern of growth to the long-term linear growth. From 2013-2015, the same percentages of growth were used for Yuma, however the base number was annualized growth from 2000 to 2010 instead of linear growth. The full annualized growth rate was used between 2016 and 2050.

Eight CDPs[7] where growth is deemed unlikely were set at a constant population level from 2012 through2050. In three other CDPs[8], total growth was set at 10 percent for the entire projection period, and population for years between 2012 and 2050 were linearly interpolated. Fortuna Foothills was expected to grow at a faster rate, equivalent to 70 percent of Yuma's annual growth rate. The remaining unincorporated place populations were projected using the constant share method.

4. RESERVATIONS

Using GIS analysis, we identified all places that were wholly or partly contained by a reservation's boundary and the number of people each place contributed to the reservation population based on Census 2010. The proportion of population contributed by each place was applied to the final sub-county projections and summed to produce the projection for the whole reservation. There was one slight exception to this methodology in Navajo county. The portion of small balance of county within the Navajo Reservation was projected separately and then added to the population contributions from other places within the reservation boundary.

[7] Aztec, Donovan Estates, Drysdale, El Prado Estates, Gadsden, Orange Grove Mobile Manor, Wall Lane, and Wellton Hills.
[8] Padre Rachitos, Rancho Mesa Verde, and Tacna.

5. INCLUSION OF PLACES

CAG, MAG, and PAG each made its own decision as to what places to include in sub-county projections. ADOA accepted those choices after determining that they meet the minimum requirement of Executive Order 2011-04. Working with Northern Arizona Council of Governments (NACOG), Southeastern Arizona Governments (SEAGO), and Western Arizona Council of Governments (WACOG), ADOA decided to produce population projections for all incorporated places, the unincorporated balance of counties, all CDPs, the small balance of counties, and Indian Reservations in 11 counties. Due the high degree of variability and uncertainty, it was decided that CDPs with a Census 2010 population of less than 500 be excluded in the final publication of sub-county population projections.